REMARKS

Upon entry of the present amendment, claim 9 will have been amended. Claim 19 will have been canceled without prejudice or disclaimer of the subject matter thereof. New claim 20 will have been submitted for consideration by the Examiner. Thus, claims 2-14, 16-18 and 20 are pending in the application.

In view of the herein contained amendments and remarks, Applicant respectfully requests reconsideration and withdrawal of the outstanding rejections set forth in the above-mentioned Official Action. Such action is believed to be appropriate and proper and is thus respectfully requested, in due course.

Applicant wishes to make of record a telephone interview conducted between Applicant's undersigned representative and Examiner Tejano, who is in charge of the present application, on December 6, 2010. In this regard Applicant's undersigned representative wishes to respectfully thank Examiner Tejano for his courtesy and cooperation in scheduling and conducting the above noted interview.

During the above noted interview, Applicant's representative discussed the restriction requirement apparently asserted with respect to claim 19 in the present Official Action, and indicated that most of the features of claim 19 are included in claim 9, and the features recited in claim 9 and the features recited only in claim 19 are not mutually exclusive, and there would be no "serious burden" on the examiner in examining such claims. Thus, Applicant requested the Examiner to consider the combination of the features of claim 9 and the features recited only in claim 19, if such combination of features are presented in the amendment in filing an RCE, despite the restriction requirement asserted with respect to claim 19.

The Examiner indicated that he would consider the claims including the combination of features of claim 9 and the features only recited in claim 19, and even without the feature of "quadratic curve" recited in claim 9, which will be submitted with filing an RCE. Applicant greatly appreciates the Examiner's understanding and cooperation.

In the outstanding Official Action, the Examiner rejected claims 2-5, 9-14 and 16-18 under 35 U.S.C. 103(a) as being unpatentable over Meyers (EP 0809124) in view of Huang et al. (US 2003/0044729) and further in view of Grossinger et al. (US 5227915). Claims 6-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Meyers in view of Huang et al. and Dellowo et al. (US 7,390,532). Applicant respectfully disagrees and thus traverse.

It is a design objective of digital cameras to minimize the thickness of the camera. Shortening the focal length of an optical system of an imaging lens is one manner in which the thickness of a digital camera is decreased. However, since light incident on the periphery of a solid-state imaging apparatus such as a charge-coupled device (CCD) or metal oxide semiconductor (MOS) sensor enters at an oblique angle with respect to the vertical axis of the surface of incidence, sensitivity significantly deteriorates at the periphery. To address the above-noted issue, according to one non-limiting disclosed embodiment of the presently claimed invention, the refractive indices of light-transmitting films are modulated by forming light transmitting films each having a combination of concentric zones, each of which in turn, has an arbitrary line width that is equal to or shorter than the wavelength of incident light. More particularly, effective refractive index distribution lenses having independently variable refractive index distributions for each pixel of the solid-state imaging apparatus are provided. Thus, incident light is refracted due to the position-dependent effective refractive index of the claimed light-collector.

To further elucidate the above-noted features of Applicant's independent claim 9, FIGS. A and B are provided herein. In both FIGS. A and B, shading in the illustrated effective refractive index distribution lens represents variation in a refractive index, and a density of shading represents the level of refractive index. FIG. A illustrates light collection by an effective refractive index distribution lens having *a symmetric effective refractive index distribution*. The wavefront (*i.e.,* a surface having the same phase) of light incident in the vertical direction is shown as a solid line. The refractive index is inversely proportional to the distance traveled by light; that is, the wavefront of the light passing through the effective refractive index distribution lens is curved and light is collected at the light-receiver. FIG. B illustrates light collection by an effective refractive index distribution lens having an *asymmetric effective refractive index distribution*. That is, the density of shading is shown as *being at the left of the effective refractive index lens, and not at the center of the effective refractive index lens, as in FIG. A*. The wavefront of light incident at an incidence angle θ with respect to the vertical direction is shown with a solid line. The wavefront of the light passing through the asymmetric effective refractive index distribution lens is curved as shown in FIG. B and the light is also collected at the light-receiver.

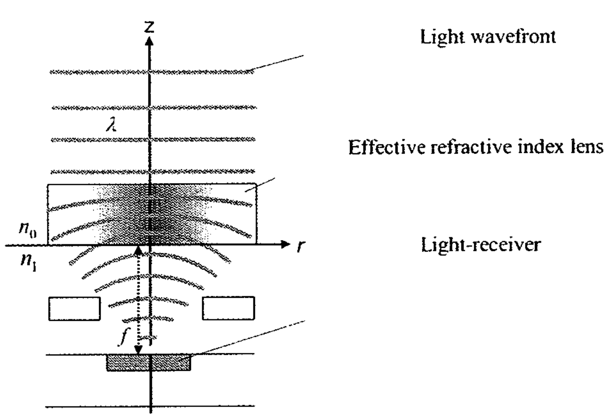

FIG. A

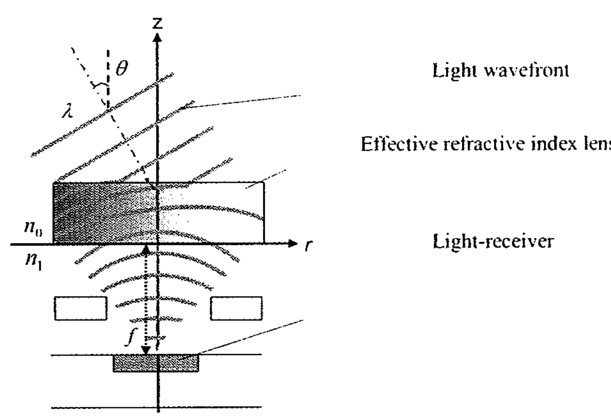

FIG. B

In the claimed solid-state imaging apparatus, in each of the light-collectors in the claimed arranged unit pixels, the center of the zones is a position at which an effective refractive index distribution of a corresponding light-collector represented by the quadratic curve reaches a maximum value matches a central axis of a corresponding light-receiver. That is, the maximum value of the quadratic curve representing the effective refractive index distribution shifts toward the center of the sensor on the light incoming side as the incidence angle of incident light increases. As shown in FIGS. A and B above, an increasing incidence angle results in a shift of the maximum value of the effective refractive index distribution from the center (*i.e.,* as shown in FIG. A) to the left (*i.e.,* as shown in FIG. B) of the claimed solid-state imaging apparatus. Thus, an optimal effective refractive index distribution is achieved for each unit pixel, which allows each unit pixel located at the periphery of the claimed solid-state imaging apparatus to efficiently collect incident light and achieve the same sensitivity as is achieved by pixels at the center of the claimed solid-state imaging apparatus, even when light is incident obliquely and with a large angle of incidence with respect to a axis transverse to the surface of incidence. *See, e.g.,* FIG. B illustrated above. Accordingly, the presently claimed invention implements a solid-state imaging apparatus that eliminates differences in light-collection efficiency due to an increase in an angle of incidence of incident light, and which has high sensitivity as well as high sensitivity uniformity.

The Examiner asserts MEYERS as teaching arranged unit pixels, a light receiver, a substrate onto which the incident light is incident, and a plurality of light transmitting films formed in a region in which the incident light is incident above the substrate, as specified in independent claim 9. The Examiner also asserts that a light-transmitting film that forms a zone in which a width of each zone is equal to or shorter than a wavelength of the incident light is

inherently present in MEYERS. However, the Examiner also acknowledges that MEYERS fails to disclose that each zone shares a center point which is located at a position displaced from a center of said light-receiver, as recited in Applicant's independent claim 9. The Examiner asserts HUANG et al. as teaching the above-noted features of Applicant's independent claim 9. The Examiner also asserts HUANG et al. as teaching that, in a unit pixel, among said unit pixels, which is located at a center of a plane on which said unit pixels are formed, a position at which an effective refractive distribution of a corresponding light-collector is a maximum value matches a central axis of a corresponding light-receiver; and in a unit pixel, among said unit pixels, which is located at a periphery of the plane, a position at which the effective refractive distribution of a corresponding light-collector is a maximum value is displaced from the central axis of a corresponding light-receiver toward the center of the plane.

Applicant's independent claim 9 recites that, inter alia, a plurality of light-transmitting films form an effective refractive index distribution represented by a quadratic curve expressed by a distance from a center of a corresponding one of the unit pixels. Applicant's amended independent claim 1 also recites, inter alia, in a unit pixel, among said unit pixels, which is located at a center of a plane on which said unit pixels are formed, a position at which an effective refractive index distribution of a corresponding light-collector represented by the quadratic curve reaches a maximum value matches a central axis of a corresponding light-receiver, and in a unit pixel, among said unit pixels, which is located at a periphery of the plane, a position at which the effective refractive distribution of a corresponding light-collector represented by the quadratic curve reaches a maximum value is displaced from the central axis of a corresponding light-receiver toward the center of the plane.

Applicant respectfully submits that HUANG et al. discloses a method of forming a

diffractive light-collector for each pixel of an image sensor. The asserted portions of HUANG et al. in FIGS. 2C and 3 are submitted to illustrate a phase grating lens 212 formed in a flattening layer 208. HUANG et al. is further submitted to disclose that each phase grating lens 212 is used to focus the incident light beam on the photosensitive device 202, (and) therefore the depth of the phase grating lens 212 and the radius of each concentric circular trench depend on where the focus is desired to be located.

However, Applicant respectfully submits that the center points of the concentric circles shown in FIG. 3 of HUANG et al. are not displaced. In contrast to the teachings of HUANG et al., each of the claimed light-collectors collects light through a difference in refractive index by achieving a symmetric or asymmetric effective refractive index distribution (depending upon location) through a corresponding light-transmitting film having an arbitrary line width equal to or shorter than the wavelength of incident light. Each of the claimed light-collectors forms an optimal effective refractive index distribution for a corresponding unit pixel by shifting the maximum value of a quadratic curve representing the effective refractive index distribution toward the center of the sensor on the light incoming side. Therefore, Applicant respectfully submits that HUANG et al. fails to disclose or render obvious at least the above-noted features of Applicant's independent claim 9.

Applicant respectfully submits that MEYERS also fails to disclose or render obvious the recited features of Applicant's independent claim 9. Applicant respectfully submits that MEYERS is directed to a structure in which downwardly-convex lenses and apertures are positioned off-center with respect to pixels at the periphery of an image sensor having an array of light-receiving devices. The downwardly-convex lenses and apertures become increasingly off-centered in an outward direction from the center of the image sensor. Even assuming,

arguendo, that MEYERS is properly interpretable as disclosing receiving incident light at the periphery of the image sensor, MEYERS is submitted to disclose that the lenses have a variable shape depending on the pixels, but that the material has a uniform refractive index, and not that the refractive index of the lens varies, depending on the pixels, as recited in Applicant's independent claim 9. Accordingly, Applicant respectfully submits that MEYERS fails to disclose or render obvious at least the above-noted amended features of Applicant's independent claim 9.

Applicant's newly submitted claim 20, which depends from claim 9, further defines that the light-collector includes a concentric ring structure including a plurality of divided areas, each formed of a pair of a high refractive index material zone and a low refractive index material zone. In each of the unit pixels, a predetermined divided area of the plurality of divided areas has a width that is a same as a width of a concentrically outer divided area, and a width of the high refractive index material zone of the predetermined divided area is wider than a width of the high refractive index material zone of the concentrically outer divided area. The claim 20 is based on, *inter alia*, Fig. 7 and paragraphs [0053]-[0055] of Applicant's originally filed Application.

None of the cited references discloses these features in the claimed combination. As noted above, MEYERS is directed to a structure in which downwardly-convex lenses and apertures are positioned off-center with respect to pixels at the periphery of an image sensor having an array of light-receiving devices. Thus, MEYERS does not disclose the low refractive index material zone and the high refractive material index zone.

HUANG et al. and GROSSINGER et al. disclose a diffractive focusing element, which is an optical element based on light diffraction, and thus, differs in effect from the light-collecting device of the present invention, which is an optical element based on light refraction. Although

neither of the references specifically disclose the dimensions, generally, a diffraction grating having a grating period of $\lambda/2n$ or below (n is a refractive index) results in significant deterioration in the diffracting function. Thus, as the lens disclosed in MEYERS is structurally different from the optical element as recited in the claims, the optical elements disclosed in HUANG et al. and GROSSINGER et al. are also structurally different from the optical element as recited in the claims. Accordingly, these references would not have lead one to provide such a structure as the concentric ring structure of the light-collecting device as recited in the claims, which has zones each having a width approximately equal to or shorter than the wavelength of incident light. Thus, it is illogical to combine the downwardly-convex lenses as disclosed in MEYERS and the diffractive focusing element disclosed in either HUANG et al. or GROSSINGER et al. to achieve an optical element based on light refraction as recited in the claims.

Moreover, as recited in claim 20, and as shown in non-limiting example of Fig. 7, each divided area is formed of a high refractive index material and a low refractive index material, and an inner divided area and an outer divided area have the same width in one light-collecting device. However, neither HUANG et al. nor GROSSINGER et al. discloses these features (see, e.g., Fig. 2C of HUANG et al. or Fig. 3 of GROSSINGER et al.).

DELLWO was not applied to disclose the above-noted features, and does not supply the deficiencies of MEYERS, HUANG et al., and GROSSINGER et al.

In view of the above, at least based on the lack of disclosure regarding the above described and explicitly claimed features, in the claimed combinations, Applicant submits that none of the cited references, even if combined, disclose or suggest the combination of features as

recited in the Applicant's independent claim 9 and new dependent claim 20, and the Examiner's rejection of independent claim 9 under 35 U.S.C. §103(a) is improper.

Each dependent claim in the present application is respectfully submitted to be patentable over the references relied upon based upon its dependence from a shown to be allowable base claim, as well as based upon its own additional recitation.

Accordingly, Applicant respectfully requests, reconsideration and withdrawal of the outstanding rejections, together with an indication of the allowability of the claims pending in the present application, in due course.

SUMMARY AND CONCLUSION

Applicant has made a sincere effort to place the present application into condition for allowance and believes that he has now done so. Applicant has amended the claims to improve language clarity. Applicant has also submitted a new dependent claim for consideration by the Examiner.

Applicant has additionally discussed the disclosures of the references and has pointed out the shortcomings thereof. Further, Applicant has, with respect to the explicit recitations of the pending claims, pointed out clear deficiencies in the references applied thereagainst. Accordingly, Applicant has provided a clear and convincing evidentiary basis supporting the patentability of all of the claims in the present application and respectfully request an indication to such effect in due course.

Any amendments to the claims which have been made in this amendment, and which have not been specifically noted to overcome a rejection based upon the prior art, should be considered to have been made for a purpose unrelated to patentability, and no estoppel should be deemed to attach thereto.

Should the Examiner have any questions or comments regarding this Response, or the present application, the Examiner is invited to contact the undersigned at the below-listed telephone number.

Respectfully Submitted,
~~Minoru Kawabata~~

Bruce H. Bernstein
Reg. No. 29,027

William Pieprz
Reg. No. 33,630

December 13, 2010
GREENBLUM & BERNSTEIN, P.L.C.
1950 Roland Clarke Place
Reston, VA 20191
(703) 716-1191